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Looking Into the Demography of an Iron Age Population in the Western Mediterranean. I. Mortality

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ABSTRACT In this paper, we attempt to reconstruct the mortality pattern of the population buried in S'Illot des Porros (Majorca), an Iron Age necropolis in the western Mediterranean, by means of paleodemographic analysis. The skeletal sample consists of 285 individuals, 93 subadults (under 20 years old) and 192 adults. The aim of this study is twofold: first, to identify and to evaluate the structural anomalies of the skeletal sample, and second, to obtain a possible and realistic description of the biological dynamics of this population, with special reference to its mortality pattern. The study uses current demographic methodology and several demographic models (for comparison). An abridged life table was built to estimate the mortality parameters. To evaluate the likelihood of the estimated data, an indirect analysis, which consisted of a comparison of our results with different population models (Weiss [1973] American Antiquity *38*; Coale and Demeny [1996] Regional Model Life Tables and Stable Populations. Princeton: Princeton University Press; Ledermann [1969] Nouvelles tables—types de mortalité. Paris: Presses Universitaires de France), was carried out. An important bias was identified in the case of children, mostly affecting infants but also children between the ages of 1 and 5. This was interpreted as a census error due to taphonomic reasons and to an excluding differential funeral rite. A life expectancy at birth of approximately 28 years was estimated from the observed data. When this bias was removed, the estimated life expectancy at birth dropped to 23 years. The use of the Brass logit system allowed us to sketch a possible mortality profile for this population: low life expectancy, high infant mortality and hard life conditions, which were the cause of the low levels of survivorship in old ages. Am J Phys Anthropol 110:285–301, 1999.

Studies in paleodemography analyze ancient human populations, and therefore they face the problems derived from the nature of the material which is studied, the skeletal remains. With the exception of some specific or more recent cases, we normally lack information about the age at death, sex or the cause of death of the individuals, as well as their relationship with the living population they belong to. Thus the reconstruction of past populations runs into two major

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problems which contribute to so-called census errors in paleodemographic data (Acsádi and Nemeskéri, 1970; Mensforth, 1990; Jackes, 1992).

The first one is the *representativeness* of archaeological samples. The ideal scenario is one in which the skeletal sample equals a complete record of deaths of this population, that is, one in which all the individuals were buried in the cemetery and the burial was not selective because of age and/or sex considerations. However, this is rarely the case, and we often lack information about the relationship between the skeletal population and the biological population that it represents; that is, we do not know how well the skeletal population reflects the reality of the living population. Moreover, we normally lack information about taphonomy, archaeological recovery and some non-random selective factors related to burial customs which determine whether the skeletal sample is representative of all those who died in a population at certain period in time. These factors can, however, be estimated from the evidence, and thus be evaluated and interpreted.

The second problem deals with attributing *age and sex* to the individuals. Often, we work with estimates of these two parameters. This introduces some biases which can distort in different ways the actual age-at-death structure of the skeletal sample studied. All these problems have been widely discussed by different authors in the literature (Weiss, 1972; Howell, 1976; Bocquet-Appel and Masset, 1982, 1985; Van Gerven and Armelagos, 1983; Buikstra and Konigsberg, 1985; Greene et al., 1986; Walker et al., 1988; Mensforth, 1990; Jackes, 1992; Konigsberg and Frankenberg, 1994).

Because of these difficulties some researchers have questioned the validity and use of paleodemographic studies to provide a realistic assessment of the life conditions of ancient populations. Despite the limitations that paleodemographic studies present, the potential information that they can provide is a useful key to understanding not only the composition and dynamics of these populations but also their interrelationship with their social and physical environment (Buikstra and Mielke, 1985). In this paper we undertake a paleodemographic study of a fairly complete and interesting population from an archaeological and anthropological viewpoint, using the available current demographic methodology, adapted to take into account the specific nature of our data. The aim of the study is twofold: first, to identify and evaluate the structural anomalies of the skeletal sample, and second, to obtain a possible and probable vision of this population's biological dynamics.

MATERIAL AND CHRONOLOGICAL FRAME

The skeletal remains used in the present study come from the necropolis of S'Illot des Porros in Majorca (Spain). Culturally this necropolis belongs to the so-called late "talaiothic" period—the autochthonous culture during the European Iron Age—and has "pretalaiothic" antecedents. This culture is characterized by megalithic or cyclopean constructions. Some of the most significant are the ones used as urban watch towers, the so-called "talaiot" constructions, after which the period is named. Archaeological data reveal that the inhabitants of Majorca during this period were organized in small population nuclei composed of different families. Their economy was based on cereal agriculture and farming and was supplemented by the exploitation of marine resources. Their culture, however, was open to innovations derived from their commercial contacts with Phoenicians, Carthaginians, and Greeks. From the fifth century BC the inhabitants of Majorca were renowned for their service as mercenaries in the Carthaginian army during the Greco-Punic wars and also later on during the Punic wars between Rome and Carthage. These contacts contributed also to the introduction of new rites and customs such as incineration (Tarradell, 1964; Fernández-Miranda, 1978; Hernández, 1998). Despite the largely homogeneous characteristics of the talaiothic culture, we witness very complex and varied funeral rites and so different rituals actually coexist during the same chronological period, on the same island and even in the same necropolis (Rosselló-Bordoy and Guerrero, 1983). Different burial sites can be found on the island of Majorca that date

back to late talaiothic period. Most of them contain burials of small groups. Three sites, however, stand out by their peculiarity and the number of inhumations: the necropolises of S'Illot des Porros and Son Real in the north, and the funerary site of Son Oms in the south. All of them are outdoor, non-collective necropolises, and the first two constitute two big funerary ensembles characterized by a particular and unique building technique found on the island (Pericot, 1975; Fernández-Miranda, 1978).

The necropolis of S'Illot des Porros is located on a islet which is situated about 100 m north of Majorca. The islet is a flat rock of approximately 3,040 m^2 which rises a few meters above sea level. The necropolis consists of a small burial area without built structures and three cyclopean sepulchral chambers (A, B, and C): two of these chambers are excavated in the rock and the third is only delimited by a wall of large and undressed stones. These chambers have an ill-defined circular form and contained cremations as well as burials. It is important to note that while cremation alone prevails in the rest of Mediterranean, in this particular necropolis we see the coincidence of two funeral rites. It is this association, together with its building peculiarity that makes this necropolis unique in the area.

Chronologically, our necropolis dates back to between the fourth century BC and the second century of the Common Era. Before the fourth century BC a necropolis with small monuments, now lost, existed on the islet. This necropolis was destroyed prior to the building of the big funeral chambers A, B and C. Around the fourth century BC chamber C was built for burials. Between the third and second centuries BC the two other chambers (A and B) were built and used simultaneously with C. From this moment two funeral rites (cremation and burial) coexisted in the necropolis. Chamber C continued to be used until the first century BC and the other two until the first century of the Common Era or even the first half of the second century, well into the Roman period. Between the second and first centuries BC cremation stopped and only burials (in chambers A and B) continued to be used. Around this time they started burying outside the chambers in individual pit graves (Hernández et al., 1998). Unfortunately, the stratigraphy of the site does not allow us to assign specific chronological subperiods to the burials during the 500 years of use of the necropolis. All the burials were primary, the bodies were placed in fetal position and some seemed to be laid down tied or in a shroud. All the burials were individual, but in the three big chambers they shared the same sepulchral space. Cremations were primary and individual, they never actually achieved incineration and it looks as if the corpse was cremated fully dressed and with all the ornaments (Hernández, 1998).

While both cremation and burial coexisted for some time, burials were actually predominant. The reason why some individuals were cremated and not buried is unknown, as there is no clear evidence of a differential funeral rite depending on social status. Statistical analysis (chi-square test) has also shown that there are no significant differences between both types (cremation and burials) due to age ($P = 0.50245$) or sex ($P = 0.8377$).

The anthropological material of S'Illot des Porros was recovered during various field seasons. Initial excavations were undertaken in the 1960s by a crew managed by the archaeologist M. Tarradell, under the auspices of the William L. Bryant Spanish-American Foundation. In recent years, 1996 and 1997, the excavation of the archaeological site was completed. The anthropological study of the human skeletal remains has been ongoing since the 1980s, and issues related to morphological, pathological and typological aspects, sexual dimorphism, paleodiet and child development have already been discussed and analyzed (Malgosa, 1985; Alesan, 1990; Pérez, 1990; Carrasco and Malgosa, 1990; Malgosa and Campillo, 1991; Castellana and Malgosa, 1991; Subirà and Malgosa, 1992; Rissech and Malgosa, 1997). Part of the material used in the present study comes from the last two field excavations and therefore its anthropological study is still unpublished. A total of 285 skeletons were identified, 93 subadults (under 20 years old) and 192 adults.

METHODS

To reconstruct the structure of the population buried in this necropolis two parameters are essential: the age and sex of skeletal remains. Both the cremated and buried skeletal remains found were subjected to age and sex diagnostics.

Age determination

Skeletons have been classified into seven general age categories: four subadult [infant (under 1), child I (1–4), child II (5–12), juvenile (13–19)] and three adult [adult (20–39), middle age (40–59), old age (60–*w*)].

Subadult skeletons. To classify the subadult skeletons, the recommendations suggested by Ferembach et al. (1980) and the criteria described by Krogman and Iscan (1986) were followed. In the case of subadult skeletons up to 12 years, the dental development criterion was preferred (Crétot, 1978; Ubelaker, 1989). The degree of development and closure of occipital synchondrosis (Redfield, 1970; Testut and Latarjet, 1975) as well as temporal tympanic plate development (Weaver, 1979) and maximum diaphyseal length of long bones (Stloukal and Hanáková, 1978; Alduc-Le Bagousse, 1988) were used as secondary criteria. Over the age of 12, preference was given to the skeletal criterion based on the degree of ossification and epiphyseal union of long bones (Brothwell, 1981; Ferembach et al., 1980; Krogman and Iscan, 1986).

Adult skeletons. To classify the adult skeletons, the recommendations suggested by Ferembach et al. (1980) were followed, and the multifactorial approach was preferred. Then, the degree of cranial sutures synostosis (Masset, 1982), dental wear (Brothwell, 1981), morphological changes of the pubic symphysis (Meindl et al., 1985; Krogman and Iscan, 1986), and metamorphosis of auricular surface of the ilium (Lovejoy et al., 1985) were employed.

Sex diagnosis

Given the difficulties inherent in the identification of sex in immature skeletons, and that no consensus exists on the methodology that should be adopted, sex diagnosis was not attempted in the case of subadult skeletons (infants and children). With juvenile and adult skeletons, the classic criteria put forward by Martin and Saller (1957) and Olivier (1960) were adopted. That is, sexual diagnostic characteristics of the os coxae, cranium, and jaw were used as the main criteria (Ferembach et al., 1980; Taylor and Dibennardo, 1984; Rissech and Malgosa, 1997). In addition, long bone metrics i.e. femora or tibiae (Black, 1978; Iscan and Miller-Shaivitz, 1984) were used. Only 13% of juvenile skeletons could be sexed due to poor preservation of the diagnostic bones.

Demographic methodology

To undertake a demographic study of the population, the following assumptions were made. First, that the cemetery was used by only one population, community or group and that they did not use other cemeteries at the same time; second, that all the individuals of that community were buried in the necropolis; third, that the archaeological excavation was complete and anthropological recovery was meticulous and not differential; and finally, that entrances (by births) balanced exits (by deaths) and that there were no differences between both in terms of age and sex structure. Without these assumptions, paleodemographic reconstructions are not possible. We therefore assume that the systematic bias is as small as possible or is conditioned neither by the age nor the sex of individuals. That is, our skeletal population is representative of the living population who died in this community. These assumptions are a prerequisite to test the hypothesis that we are working with a good death register and also to test the validity of our results.

To evaluate our mortality data for S'Illot des Porros, two methods of analysis were followed. The first one was a direct analysis of the observed data. The second, an indirect analysis through comparison with various population models which represent different mortality patterns.

An abridged life table, combined for both sexes, was created. This table allowed us to obtain a statistical description of mortality and was used for comparison with other population models which allowed us to evalu-

ate our data. The life table is a probabilistic model that describes the extinction by death of a *cohort* by ages. It also allows us to estimate conventional mortality parameters such as life expectancy at birth. In the case of the skeletal record of our community, the life table summarized the extinction of all generations that died in the community during a period of time. Throughout the existence of this community and therefore throughout the period of use of this burial, this population could have experienced differences in growth. However, our skeletal sample is a representation by age and sex of the deaths of that community throughout all the period of use of the cemetery (almost five centuries). By associating the observed structure to a stationary life table we can avoid the conjunctural or moment effect with the result that the mortality structure represents all the generations that lived in that community. So in this life table, births are constant and equal deaths. Therefore, throughout the period of use of the cemetery this population is characterized by zero growth. This last assumption, which is necessary to associate our table to the corresponding stationary table, would be the one that would best represent the type of growth of these populations.

The use of life tables implies two assumptions. The first one, that age-at-death structure obtained is real. The multifactorial criterion used in the present study minimizes the bias in determining the age structure of the population under study. The second assumption is that this population is in fact stationary. In this case this was considered to be appropriate because populations in ancient times were supposed to have almost zero growth rates and to be more stable as far as mortality was concerned (Acsádi and Nemeskéri, 1970).

Following current methodological practice, our life table was constructed using 5-year age intervals. However, as it was not always possible to have such narrow age intervals, the intervals used for adults were wider (20 years). This was done to minimize the possible errors in age estimation (mainly in middle-aged individuals) and allows us to include poorly preserved skeletons and therefore increase the total number of observations. Five-year age intervals were obtained by cubic interpolation (Burden and Faires, 1985) from the cumulative d_x, and the relative d_x was calculated by means of displaying the interpolated cumulative d_x (Valverde and Bush, 1992). Cubic interpolation was considered the most appropriate technique in our case since it better reproduces demographic profiles. Age diagnostic in the old age group (over 60) does not allow us to assign clear intervals and so we established a reasonable upper limit of 80 years as the maximum age that the oldest person could possibly have reached in this community.

To estimate some demographic parameters (e_0 life expectancy at birth, ${}_1q_0$ probability of dying between birth and the age of 1, and ${}_5q_0$ probability of dying between birth and the age of 5) the so-called juvenility index (Bocquet, 1979; Bocquet and Masset, 1977; Bocquet-Appel and Masset, 1996) was also calculated as the ratio between the number of deaths between the ages of 5 to 14 years and the number of deaths after the age of 20 (D_{5-14}/D_{20-w}). This index allows us to estimate the demographic parameters without the bias due to infant underrepresentation in osteological collections and also to control for systematical bias in the calculation of adult age distribution.

The indirect analysis of our mortality data relied on comparison with three population models (Ledermann's, Coale and Demeny's, and Weiss' model life tables). Ledermann's model life tables (1969) have great flexibility and the advantage of having a great variety of mortality models and evaluating the estimation bias. Coale and Demeny's model life tables (1966) are very frequently used in modern demography and they summarize the mortality patterns in four regional models. However they can present some problems if they are used to analyze past populations because they are based on mortality patterns that include few data about underdeveloped populations and use only data after 1870. Weiss' model life tables (1973) have the advantage, but also the disadvantage, of providing mortality models—for the range of ages 0 to 54—based on different collections of ancient skeletal remains and different ethnographic populations. For ages

TABLE 1. Composition by ages and sexes of S'Illot des Porros skeletal sample

Age group	Sex	N
0		2
1–4		23
5–9		22
10–14		20
15–19		26
20–39	males	50
	females	61
	indeterminable	15
40–59	males	30
	females	19
	indeterminable	3
60–w	males	10
	females	3
	indeterminable	1
Total subadults		93
Total adults		192
Total males		90
Total females		83
Total		285

55 and over, they are based on Coale and Demeny's model West.

Finally, to determine the adult mortality pattern of our population, the Brass logit system (ONU, 1984) was used. This method allows us to adjust the observed mortality to a given mortality model as well as to estimate the juvenile mortality. The Brass logit system is based on the generation of different life tables through logit transformation of survivorship values of a suitable standard or normative life table, according to the expression

$$l^* = (1.0 + \exp(2\alpha + 2\beta\lambda(l_x)))^{-1}$$

where l_x is the survivorship value of the standard or normative life table; ;$\lambda(l_x)$ is the logit transformation of the standard; α β are the parameters, obtained by linear regression, which define the best fit to the model; and l^*_x is the survivorship value that allows us to obtain the adjusted life table parameters.

RESULTS AND DISCUSSION

The composition by ages and sexes of the studied series is summarized in Table 1, while Table 2 shows the computed life table.

The sex ratio at different ages is used to associate our distribution by sex and age of the skeletal remains to the survivorship curve of this population. A sex ratio of 108 men by 100 women, which represents 52% of males, was found. This value is not far from the range 100:100–105:100 of expected proportions and thus it is considered to be within the normal variability range. From this, we conclude that both sexes are quite well represented in the skeletal remains of S'Illot des Porros. The sex ratio computed by age groups was 82:100 in the young adult population, 158:100 in the middle aged group, and 333:100 for ages over 59. The higher proportion of female skeletons in adult age corresponds to an increase in mortality during the reproductive age span which, in turn, relates to complications during gestation, childbirth, and during the nursing period. The larger proportion of male skeletons from middle age can be due both to an increase in male mortality and to the fact that the possibility of reaching these ages in males is higher. However, if this distribution is associated to a survivorship curve we can easily explain this as the result of a combination of both effects. Female overmortality, due no doubt to problems related to pregnancy, affects more significantly the reproductive years (20 to 40).

Examination of the estimated life table (Table 2) reveals a survivorship curve typical of preindustrialized societies prior to the demographic transition and with an archaic demographic regime (high rate of deaths in all ages and short life duration). However, the curve of l_x is affected by the practical absence of deaths during the first year of life and the probable underrepresentation between the ages of 1 and 5. Parallel analysis of the d_x and q_x columns also shows a loss of individuals in these age groups. Indeed, the sample suggests that subpopulation of deceased infants—those who have not reached their first birthday—is almost absent, and that children between the ages of 1 and 5 also seem to be affected by underregistration, although to a lesser extent. In fact, between birth and the age of 1 only two individuals were accounted for. However, due to biological reasons we would have expected to find a higher number of individuals because the estimated high mortality rate would be concentrated in this age range. If we were to go by the data from life table, we would have to assume that only 0.7% of individuals would have died in their first year of life. However, the expected values

TABLE 2. S'Illot des Porros abridged life table combined for both sexes

x	${}_nD_x$	${}_nd_x$	${}_nd_x^1$	l_n	${}_nq_x$	${}_nL_x$	e_x	${}_nC_x$
0	2	0.702	0.702	1000.000	0.007	996.491	28.538	3.492
1	23	8.070	8.070	992.983	0.081	3810.526	27.736	13.352
5	22	7.719	7.719	912.281	0.085	4368.421	26.013	15.307
10	20	7.018	7.018	835.088	0.084	4000.000	23.187	14.016
15	26	9.123	9.123	764.912	0.119	3596.491	20.085	12.602
20	126	44.211	11.028	673.684	0.164	3092.716	17.466	10.837
25			11.851	563.402	0.210	2520.749	15.395	8.833
30			11.464	444.897	0.258	1937.890	13.830	6.790
35			9.868	330.259	0.299	1404.595	12.763	4.922
40	52	18.246	7.359	231.579	0.318	973.928	12.136	3.413
45			5.118	157.992	0.324	662.017	11.624	2.320
50			3.441	106.814	0.322	448.047	10.996	1.570
55			2.328	72.405	0.322	303.818	10.033	1.065
60	14	4.912	1.708	49.123	0.348	202.908	8.604	0.711
65			1.297	32.040	0.405	127.785	6.858	0.448
70			1.022	19.074	0.536	69.811	4.820	0.245
75			0.885	8.851	1.000	22.127	2.500	0.078
Total	285							

[1] Values after interpolation.

should have been between 30 and 50% (Angel, 1969; Bennike, 1985; Brothwell, 1986–87; Trinkaus, 1995). Therefore, the life table reveals the absolute lack of representativeness of endogenous infant mortality. This pattern contrasts sharply with the data from age 5 or over, which reflects the expected mortality. In the adult subsample we note that the increase of deaths is accelerated between the ages of 20 and 35. This coincides with the inflection point of probability of dying between the ages of 20 and 25. Over 54, survivorship is insignificant, so there were very few individuals over 59 and almost no one who lived to 70 or 75. Having analyzed this distribution by age and sex, we think it is possible to assume that over the age of 5, the distribution by age could well represent the real survivorship curve of this population.

Life expectancy at birth was calculated at approximately 28 years and the crude death rate was 35.3‰. These values show very high mortality and low life expectancy, which conforms to the expected values for ancient populations such as this one (Acsádi and Nemeskéri, 1970; Weiss, 1973). This life expectancy at birth from observed and interpolated data was compared with two new estimated values. The first one is a maximum value of life expectancy which represents the optimal survivorship. That is, we assumed that individuals would live up to the maximal limit of the age interval. The second one is a minimum value of life expectancy which represents the highest probability of dying. In this case we assumed that individuals would die at the beginning of each age interval. Both values represent the limits of life expectancy between which the interpolated data can fluctuate. These new estimated values were 33.7 years in the first scenario and 24.6 years in the second one. Since our computed life expectancy value ranged between these two values, our interpolation was validated. When we estimated the life expectancy at birth from the juvenility index (Bocquet-Appel and Masset, 1996), we obtained a value of 23 years. As we observed in the case of infant underrepresentation, this new estimation is closer to the lowest limit of life expectancy that we calculated above.

To examine possible discrepancies, the population structure of the skeletal sample was compared with some populational models. The selection of these models was based on the estimated values of life expectancy at birth (e_0) in S'Illot des Porros:

1) Ledermann's model life tables (1969): in the present study net 100 and three different values for the entrance parameter (e_0) were used: a) $e_0 = 23$: this is the estimated value from the juvenility index in our population; b) $e_0 = 28$: this is the average value that Acsádi and Neméskeri (1970) give for populations of the same chronology as that of S'Illot des Porros. Incidentally, this is the

same value obtained when e_0 is estimated from the life table; and c) $e_0 = 30$: this is the greatest value for preindustrial and prejennerian populations and the lowest for contemporary developing populations (Gage et al., 1989).

2) Coale and Demeny's model life tables (1966): combined model life tables for both sexes were obtained and used for the following Coale and Demeny's regional models: a) model West: this is the regional model recommended for ancient populations (Howell, 1976). The mortality level used was 3 and its $e_0 = 23.93$ is closer to our estimates; and b) model South: this is the regional model based on data from the South Europe and has a different infant mortality pattern. The mortality level used was 2 and its $e_0 = 22.53$ is also close to our estimates.

3. Weiss' model life tables (1973): we considered the following models according the two entrance parameters, e_{15} and l_{15}: a) MT: $e_{15} = 20$ and $l_{15} = 70$. This model was chosen based on the entrance parameter values obtained from S'Illot des Porros' life table; and b) MT: $e_{15} = 35$ and $l_{15} = 50$. This model was chosen based on Ledermann's model net 100 and $e_0 = 30$.

In the comparison of the mortality data from S'Illot des Porros with these populational models (Figs. 1–3) three main biases were identified: 1) a deficit of individuals under 5; 2) an excess of subadults between the ages of 5 and 20; and 3) a deficit of old age individuals.

Deficit of individuals under 5

The first bias we observed was the underrepresentation of infants, and this emerges regardless of the populational model we compare our data to. After comparison of our results with the Ledermann's model (entrance $e_0 = 23$), we obtained the greatest deficit: it was a 33.5%, which means a deficit of 96 individuals under 1, and 18.66% or 53 individuals between ages of 1 and 5. According to this model, we should have had 174 children between birth and the age of 5 years instead of the 25 we have. Weiss' model MT:20–70 yielded the smallest deficit, with a loss of 36 individuals under 1 and practically none in the 1–4 age group. These are the expected results since this model was chosen according to the parameter values computed in the population under study. An intermediate model (Coale W3) yielded a deficit of 32% between birth and the age of 1 and 6.3% between the ages of 1 and 5, which implies a loss of 110 individuals under 5. We do not actually know what the real infant mortality model of ancient populations is, but according to observed patterns in preindustrial populations we should expect high infant mortality. In fact, we should expect a higher probability of dying during the first year of the life for endogenous reasons. And we should also expect a higher probability of dying during the early years for exogenous reasons related to the development of immunological system and the response capacity to environmental aggressions (mainly infections, parasites and gastrointestinal disorders). The practical lack of medical and hygienic practices in these populations could also be responsible for the infant mortality. Breastfeeding, the length of breastfeeding period, and the mother's nutritional status also determine mortality during the early years since suckling provides an important immunological protection for the child and prevents deaths due to malnutrition and infectious diseases. However, once weaning takes place, the child is less protected against external danger and the risk of disease and death increases.

Regardless of whether we consider that greater mortality exists between birth and 1 year (the pattern found in most of the models discussed), or between the ages of 1 and 5 (as in the Coale and Demeny's South model) one thing is clear: that children between birth and 5 years are underrepresented in our population, and that this underrepresentation is greater in the 0 to 1 year age group. How can this be explained? We suggest two possible and nonexcluding main causes:

a) Taphonomic reasons (Guy et al., 1997). Since the necropolis of S'Illot des Porros is situated in a place easily exposed to erosion and with many shallow burials, it seems reasonable to suggest that taphonomic processes could explain a large part of infants "disappearances."

b) The existence of an excluding differential funeral rite. It is not likely that infants in the talaiothic culture received different

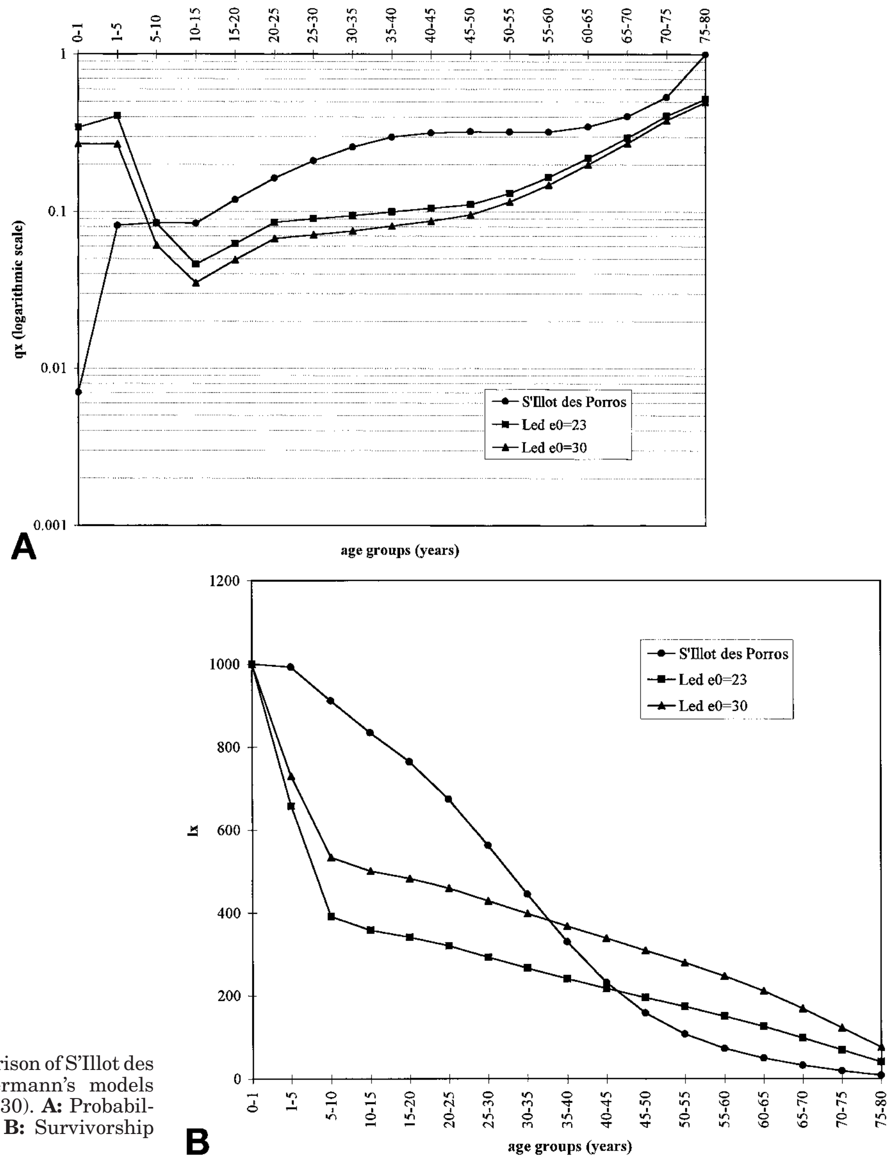


Fig. 1. Comparison of S'Illot des Porros and Ledermann's models (e_0 = 23 and e_0 = 30). **A:** Probability of dying (q_x). **B:** Survivorship curve (l_x).

mortuary treatment, since they were buried near adults and the same funeral rite was used (Guerrero, 1989). In S'Illot des Porros, where cremation and burial rites coexist, we cannot propose a differential treatment of infant remains. However, what cannot be discarded is a discrimination and probable social veto to the access to the funeral rite and place of burial (Hernández, 1998). For instance, we note the absolute absence of fetal or perinatal remains, which could have been ritually excluded from burial in the necropolis.

There is also a third, but less likely, cause we can discuss briefly. Since we are dealing with skeletal remains recovered largely during the 1960s, one could think that the methodology applied could be responsible for some losses of skeletal remains. Perhaps the careful procedures required to recover infant bones were not employed and this, coupled with a lower interest for immature

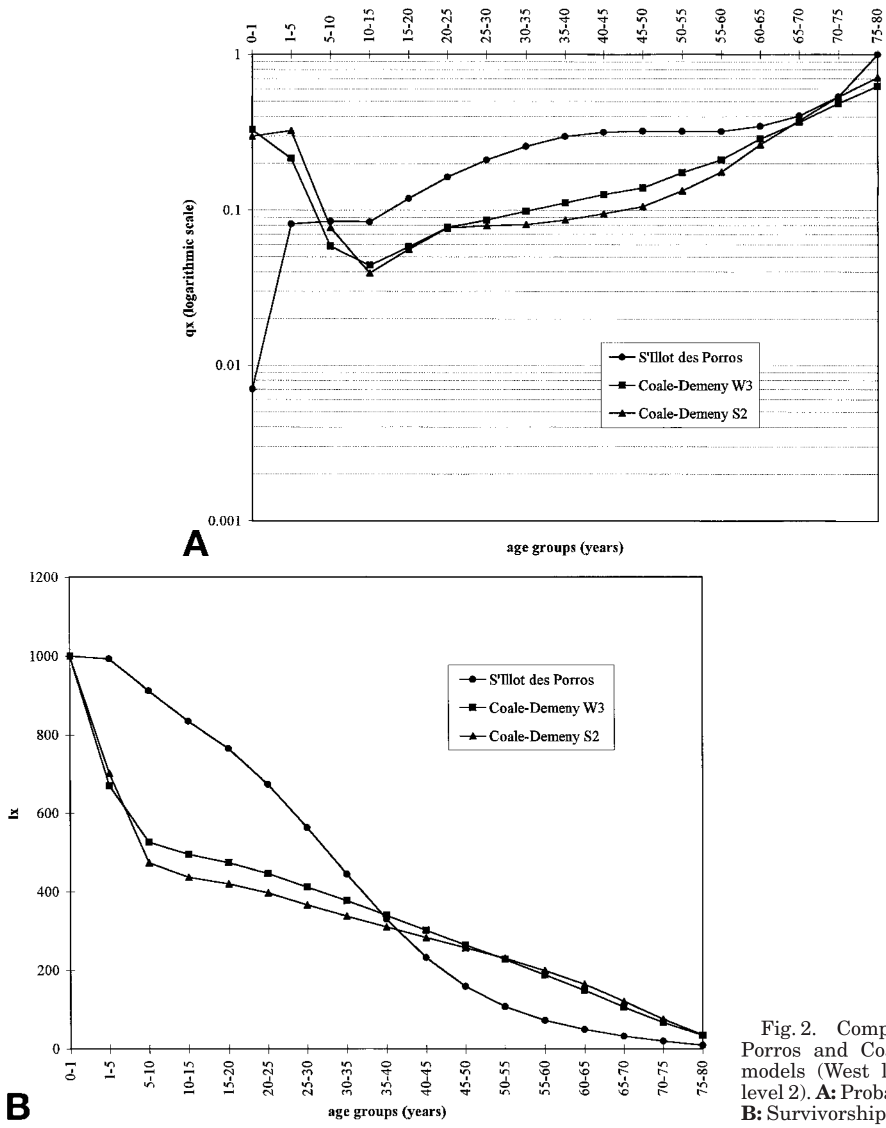
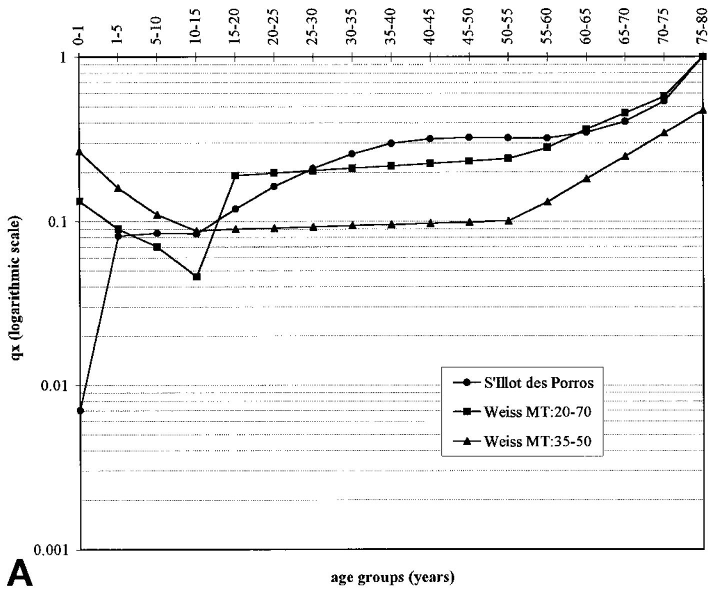


Fig. 2. Comparison of S'Illot des Porros and Coale and Demeny's models (West level 3 and South level 2). **A:** Probability of dying (q_x). **B:** Survivorship curve (l_x).

bones at the time, could explain some of the losses. However, these possible losses could not have been meaningful since most of infant remains we analyzed were recovered in the 1960s.

In any case, it seems clear that the computed e_0 value cannot be used as a realistic indicator of life expectancy and mortality in the community. Life expectancy at birth from the juvenility index was approximately 23 years (range: 21.5–24.5) and this value contrasts markedly with the 28 years computed from the life table. The smaller value obtained when we remove the bias ties in with a higher expected infant mortality. However, this value is lower than the computed value for Iron Age or classic period populations given by Acsádi and Nemeskéri (1970) ($e_0 \cong 28$ years) based on archaeological series whose infant bias is unknown. This value is closer in fact to the estimated value for populations with similar chronology (Table 3) such as Pontecagnano (Lombardi Pardini et al., 1984) or Medieval populations such as Serris (Guy, 1995) or Sézegnin (Simon, 1986). Note that this new value of



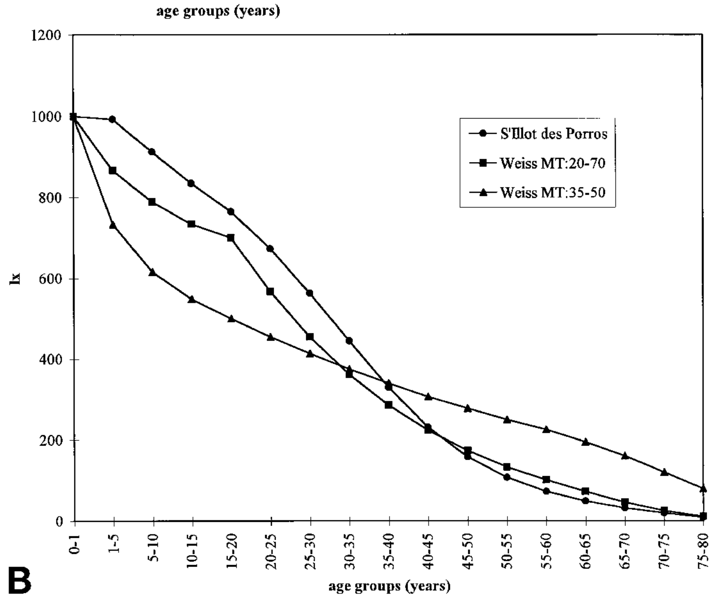


Fig. 3. Comparison of S'Illot des Porros and Weiss' models (MT: 20–70 and MT:35–50). **A:** Probability of dying (q_x). **B:** Survivorship curve (l_x).

life expectancy at birth coincides with the lower value estimated when we assume a scenario with the highest mortality. The values obtained for ${}_1q_0$ and ${}_5q_0$ were 287.1‰ and 464.1‰, respectively, when they were estimated from the juvenility index in S'Illot des Porros. These values show that the estimated mortality when the bias for the infant underrepresentation between birth and the age of 5 is eliminated is closer to the expected mortality values in the different models examined. Interestingly, these values are also closer to the ones observed in the synchronic populations cited above which also have infant underrepresentation.

Excess of subadults between ages 5 and 20

The second bias was an excess of 2% to 7% of subadults between ages of 5 and 20 in each 5-year group. Since d_x is a relative percentage, this excess could be an artifact

TABLE 3. Comparison of some demographic parameters between S'Illot des Porros and other skeletal series

Series	Chronology	JI = $D_{5\text{–}14}/D_{20\text{-}w}$	e_0[1]	e_0[2]	$_1q_0$[1]	$_1q_0$[2]	$_5q_0$	Reference
Castiglione (Lazio, Italy)	9th cent. BC	0.14	31.06	31.01	0.0455	0.2387	0.03	Salvadei and Macchiarelli 1994
Pontecagnano (Campania, Italy)	7th–6th cent. BC	0.26	15.25	20.16	0.1369	0.3043	0.15	Lombardi Pardini et al. 1984
Osteria dell'Osa (Lazio, Italy)	9th–7th cent. BC	0.14	32.51	31.01	0.0099	0.2387	0.04	Salvadei and Macchiarelli 1994
classic period (Athens + Corinth)	6th–3th cent. BC	0.163	24.701	28.19	0.2683	0.2557	0.37	Angel 1969
Ruelles de Serris (France)	7th–10th cent.	0.221	—	22.4	—	0.291	—	Guy 1995
Sézegnin (Avusy, Switzerland)	5th–6th cent.	0.24	—	21.47	—	0.296	—	Simon 1986
S'Illot des Porros	4th cent. BC–2nd cent. AD	0.219	28.386	23.02	0.007	0.2871	0.044	present study

[1] Computed from life table.
[2] Computed from Juvenility Index (JI).

and could reflect a compensation for deficit found in preceding age groups. However, it could also reflect a real situation where mortality between the ages of 5 and 20 is higher than the expected mortality; that is, a scenario in which none of the chosen models fits the observed subadult (over the age of 4) mortality pattern in S'Illot des Porros. Our mortality profile, though, fits the demographic profile of all compared models (except Weiss MT:35–50); that is, the subadult mortality fulfills the following conditions: it remains low between the ages of 5 and 15, it reaches its minimum at 10–14 age group, and then it begins to increase from this age and continues into adulthood.

Deficit of old age individuals

The third bias identified was a deficit of old age remains in relation to compared models. This loss of individuals over 59 ranged from five individuals, if we chose Weiss' model MT:20–70, to 28 individuals if we chose Ledermann's model (entrance e_0 = 30). However, in contrast with what happens with infants, this could actually reflect the "real" situation of the population, as there is a short life expectancy and low probability of reaching old age. It could also be related to hard life conditions and maybe to "sociocultural" factors associated with the care of the elderly, their importance in such societies, and a different conception of death. However, we cannot rule out the possibility that methodological factors related to difficulty or uncertainty in determining age in this group could be the underlying cause for this bias. One possibility is that the methodology has led us to underestimate the age and the number of individuals in these age categories (Bocquet-Appel and Masset, 1982). Paleopathological data, however, support the hypothesis of a young population under hard life conditions. The relatively low frequencies of vertebral arthrosis or other degenerative diseases related to aging, and the high frequency of vertebral lesions related to Schmorl's nodes, disc hernias or trauma, more frequent in males, are some of the supporting paleopathological evidence on this issue (Malgosa and Campillo, 1991; Castellana et al., 1991).

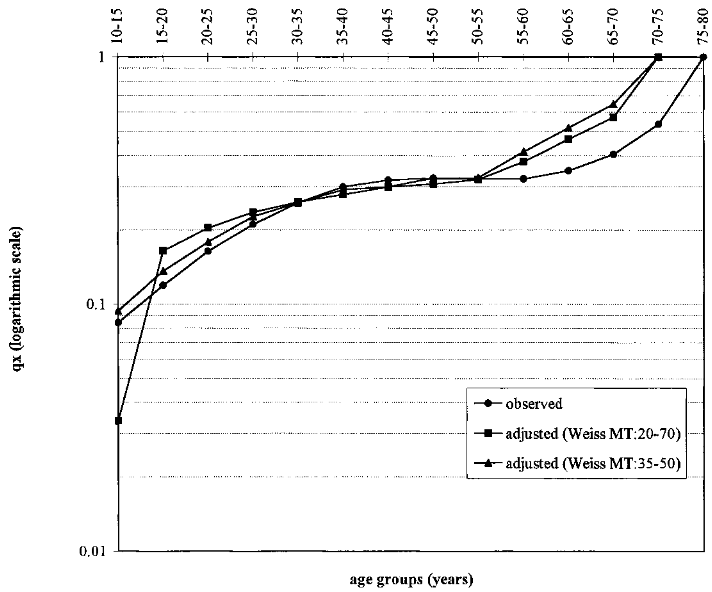


Fig. 4. Probability of dying (q_x) in S'Illot des Porros when Weiss' models (MT:20–70 and MT:35–50) are adjusted.

Which model could adjust the adult mortality of S'Illot des Porros, then? To have a description of its mortality, an adjusted mortality profile was obtained following the Brass logit system and taking the different compared models as the norm. The two Weiss' models fit best, with a progressive increase of mortality from the 20–24 age group, which runs parallel to decrease of survivorship in these groups. When we compared the probability of dying at these ages (q_x) (Fig. 4), we observed a perfect fit between the ages of 20 and 55 (particularly model MT:35–50) with a gradual and smooth increase from 25 years to the 35–39 age group. In the model, the probability of dying increases more quickly from 55. This suggests a deficit of individuals of these ages or a lower mortality with respect to the model, as was mentioned above. The probability of dying in the 35 to 55 age range is close to 100‰ and slightly higher than those in models like Ledermann's (entrance $e_0 = 30$). The maximum probability of dying is reached earlier in S'Illot des Porros than in the Ledermann's model due to the fact that the final life limit chosen here was 80, while in the model this limit extends some more years.

This adjustment also allows us to estimate juvenile mortality. The two Weiss' models define juvenile mortality patterns slightly differently when compared with the population under study (Fig. 4). S'Illot des Porros shows fewer individuals between the age groups 10–14 and 15–19 than those in the Weiss' model MT:35–50. However, when compared to the Weiss' model MT:20–70, S'Illot des Porros shows an increase of individuals in the 10–14 age group with respect to the norm, the deficit between the ages of 15 and 20 is higher and this pattern continues into the next age group (20–24 years). That is, in the first case we expected a slightly higher juvenile mortality than observed, while in the second case the expected juvenile mortality model is precisely the reverse of the observed. If we look at the probability of dying (q_x) at juvenile ages, this is quite similar to Weiss' model MT:35–50, with a progressive increase from 10 to 20 years. Thus the estimated juvenile mortality model of S'Illot des Porros would approach the Weiss' model MT:35–50, with mortality increasing smoothly and progressively from the age of 10, and a probability of dying at 10 close to 80‰.

The next question is therefore to determine the infant mortality model. It is widely known that with the same adult mortality model we can have different infant and child mortality curves. In the case of S'Illot des

Porros, we would expect high mortality in the group ages under 5, as the models suggest, and as expected due to the hard life and environmental conditions of ancient populations. Since we only have a register of exogenous infant mortality, the main causes for such high infant mortality could be the environmental stress and epidemiological load of such populations, especially in the infant segment. As in most preindustrial societies, these were mainly infectious and parasitic diseases as well as diseases related to nutritional deficiencies and trauma (Bourgeois-Pichat, 1951; Brothwell, 1986–87). Some paleopathological data, such as the high frequency (88%) of *cribra orbitalia* in ages under 5 (Alesan, 1990), lend support to the hypothetical high infant mortality in S'Illot des Porros. However, the analysis of other stress indicators, such as dental enamel hypoplasias, reveals that prevalence is relatively high at population level (37%) but relative prevalence is as high in adults as in young individuals (Carrasco and Malgosa, 1990). This indicates that during infancy some factors affected normal dental enamel development of such adults but these factors did not become an important cause of death, and they simply indicate hard life conditions. Moreover, although infants were all over 5 and not representative in the sample, nutritional studies in this population suggest a quite balanced and nutritious diet and do not yield significant differences related to sex or age (Subirà and Malgosa, 1992; Subirà et al., 1992). This suggests there was probably no difference in the nutritional habits in older children and that in qualitative terms they shared the same type of diet as adults. However, it is not possible to determine whether younger children received an adequate diet, and therefore whether they suffered from nutritional deficiencies which increased their susceptibility to diseases, which, in turn, could increase the risk of death. Although sociocultural factors related to the treatment of children in such populations could also have been important to explain the levels of infant and child mortality (e.g. passive infanticide), these practices are difficult to recognize (Acsádi and Nemeskéri, 1970; Harris and Ross, 1987; Mensforth, 1990; Wagner et al., 1993), and we do not have data which support the existence of such practices in S'Illot des Porros.

Since the Brass logit system does not allow us to estimate infant mortality, an infant mortality scenario was recreated. The models used show two different infant mortality patterns. The first one is defined by Coale and Demeny's model South and involves a slightly higher mortality in the 1–4 age group than in infancy. The second one, defined by the rest of the models, is characterized by lower mortality in these years, higher in infancy than in early childhood. The observed trend in S'Illot des Porros seems to follow the first model, if this is to be considered realistic. However, the estimated values ${}_1q_0$ and ${}_5q_0$ concentrate the highest infant mortality between birth and 1 year, which is supported for the second model. This infant mortality model reflects a population with a suckling period that might not extend beyond the 12 months and so the increase of disease and death risk related to weaning is likely to be more prominent during the first year of life. However, this population could also have a prolonged but insufficient suckling period which does not meet infant requirements and was not supplemented by other means. This situation would also increase risk conditions (infections, parasites) during this period. Paleopathological and diet data (Carrasco and Malgosa, 1990; Subirà and Malgosa, 1992; Subirà et al., 1992) seem to support the second model.

Having studied this population, and in the light of these results, it is now possible to evaluate the initial assumptions. First, it seems that some of the children under 5 who died in this population were not buried in the necropolis. This is the evident case of perinatals, who are absolutely absent in the skeletal sample, and also the case of infants, whose representation is only symbolic. This pattern suggests that only some infants were buried in the necropolis due to their family status or social standing. Note that the two infants were buried in old structures of one of the sepulchral chambers, and this is not found in any other child burials. There seems to be a clear exclusion of perinatals and neonatals from the necropolis of S'Illot des Porros. This cannot be said to extend to the other children, given that we do find

representatives of these age groups. With respect to children under 1, their small representation leads us to postulate a selective ritual based on social, family or cultural reasons. This implies the assumption that they were excluded from the rite or else that there is actually another burial site for these individuals. In the 1–4 age group, the bias could also be explained due to sociocultural reasons. However, the fact that they are better represented allows us to put forward an alternative explanation: that the bias does not really exist and that we are dealing, in fact, with different time spans during which children were indeed buried under the same conditions as the rest of the population, as is the case in many sites in Majorca, while at a different point in time, the children were systematically excluded. However, the impossibility of classifying the burials by chronological periods does not allow us to evaluate this hypothesis. With respect to the existence of a different burial site where the infants excluded from the other funerary area could be buried, we note that there are in fact two talaiothic necropolises in Majorca dedicated exclusively to infant burials. The first one is the necropolis of Marina Gran and the second the necropolis of Cas Santamarier. The latter is associated to the necropolis of Son Oms, where the adults were buried. In both cases, only neonatal burials or burials of very young infants are found (unpublished data, currently under study by the authors). Their existence, unique on the island and with a special significance, is linked to the introduction of new traditions which were the result of contact with western Mediterranean peoples with a strong Semitic influence (Rosselló-Bordoy and Guerrero 1983, Guerrero 1989). Although these burials have been explained as the native form of the Carthaginian *tophet,* a place used for ritual inhumations, its archaeological interpretation is still unclear. Moreover, we do not know what relationship S'Illot des Porros and these two necropolises had. While S'Illot des Porros is located in the north of the island, the latter are located in the south, near the coast of the island of Eivissa. This was a Punic island since the seventh century BC and so it is possible that the peoples in the south of Majorca were more easily influenced by this culture than those in the north.

Lastly, although the necropolis in S'Illot des Porros was excavated with an exemplary archeological methodology, we cannot discard the possibility that during these excavations in the 1960s, the period during which the larger part of the skeletal sample was unearthed, the lower interest for immature remains was the cause for the exclusion of these skeletal remains from registration and recovering. It must be noted, however, that even if this is the case, it is unlikely that this practice was systematic and an important source of bias.

CONCLUSIONS

The two methods of analysis used in the paleodemographic reconstruction of the population buried in the necropolis of S'Illot des Porros emphasize the underrepresentation of individuals between birth and 5 years. In fact, direct observation of data reveals an absolute lack of individuals under 1 and a probable underregistration of children between ages 1 and 5. The comparison with standard mortality models allows us to identify the magnitude of the bias introduced by the deficit of infants and to estimate the expected infant mortality following several different models. This bias affects the statistical estimation of parameters such as life expectancy and infant mortality, so it is necessary to work with other estimations that eliminate the infant underrepresentation problem.

Another bias is related to deficit of individuals over 59. This bias, less clear and also less important than the previous one, could have a methodological cause related to the difficulty of determining age in older ages and it introduces a distortion in the age-at-death structure obtained. However, it could also reflect a population with low probability of reaching advanced ages; in other words, a less developed community where life expectancy would not be very high and where old people would not be a numerically significant group.

Despite these limitations, the potential information that demographic profiles provide about the life conditions of a population and its relationship with its environment underscores the importance of paleodemo-

graphic reconstructions of past populations. These reconstructions are made possible thanks not only to the available demographic models and current demographic estimation techniques but also to the very important direct observation of data, which should never be underestimated.

Paleodemographic analysis has allowed us to determine that the community buried in the necropolis of S'Illot des Porros had low life expectancy at birth, close to 23 years, high infant mortality between birth and 5 years, and particularly higher during the first year of life, possibly due to early weaning. Juvenile mortality was minimal between the ages of 10 and 15 and then increased smoothly and progressively until the age of 25. The adult mortality profile that best fits this population could be an idealistic model in which there might have been a gradual increase of mortality from 25 to 35–39 age group, and where the survivorship over 59 was rare.

The methodology used in this study seems to be a valid tool for the reconstruction of the population of S'Illot des Porros because when its data are adjusted to a standard demographic model, the divergences can be interpreted. This is despite the fact that there is clear evidence that we are not dealing with a complete representation of this population, and taking into account that this is only an approximation to its paleodemography. The validity of paleodemographic studies, therefore, does not have to be judged a priori: the quality of the data and of the analyses are the factors which require evaluation in each paleodemographic study.

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